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Introduction

In order to identify the factors important for getting information requirements right, the research in information requirement analysis has investigated the analytical behavior of information analysts in specifying information requirements. One stream of research has focused on the differences between novice and expert information analysts. Richer domain knowledge and modeling knowledge have been recognized as main qualities of expert information analysts for better performance in information requirement analysis (Adelson and Soloway, 1985; Sutcliffe and Maiden, 1990; Vitalari and Dickson, 1983). Another stream of research has focused on comparing the effectiveness of various information requirement analysis techniques in specifying information requirements. However, the research results show that no information requirement analysis technique has consistently better performance than others (Kim and Lerch, 1992; Vessey and Cogner; 1994; Yadav, Bravoco, Chatfield, and Raikumar; 1988).

Currently, the research in information requirement analysis has been aware that information requirement analysis techniques should be matched to applications (Fitzgerald, 1996; Jackson, 1994; Vessey and Glass, 1994). Several frameworks have been proposed to classify information requirement analysis techniques on the basis of application types (Opdahl and Sindre, 1995; Sowa and Zachman, 1992; Vessey and Cogner; 1994). However, there has been no cognitive model of information requirement analysis explaining the relationship between information requirement analysis techniques and application types. This article argues that the knowledge of information analysts, information requirement analysis techniques, and application types are interactive factors in determining the quality of information requirement specifications. On the basis of the structure building theory of language comprehension (Gernsbacher, 1990), this article uses the conceptual modeling approach as research methodology to propose a cognitive model of information requirement analysis. The cognitive model of information requirement analysis explains the relationships among the knowledge of information analysts, information requirement analysis techniques, and application types. In addition, a framework for classifying organizational information requirement analysis techniques from the perspective of the cognitive model of information requirement analysis is suggested.

A Structure Building Model of Information Requirement Analysis

Information requirement analysis has been recognized as a process of understanding the contexts of object systems and then specifying the information requirements for the object systems (Borgida, Greenspan, and Mylopoulos, 1985; Fraser, Kumar, and Vaishnavi, 1991; Huang and Burns, 1997; Yadav, 1983). The empirical research has also shown that the analytical behavior of information analysts demonstrates a strong association among gathering information, identifying relevant facts, and conceptual modeling (Batra and Davis, 1992; Sutcliffe and Maiden, 1992). This strong association reflects that information requirement analysis is basically an understanding process.

From the perspective of human cognition, understanding is a process of building a coherent mental representation of the problem context being comprehended (Gernsbacher, 1990; Graesser, 1995; Kintsch, 1988; Ortony, 1978; Simon and Hayes, 1976). On the basis of the structure building framework of language comprehension (Gernsbacher, 1990), this article proposes a cognitive model of information requirement analysis to explicate the relationships among information analysts, analysis techniques, and applications as shown in Figure 1.

According to the structural building model of information requirement analysis, there are three important features which explain the modeling behavior of information analysts. First, coherence is the goal of information analysts in specifying information requirements. According to Collins Cobuild English Dictionary (1995), coherence is “a state or situation in which all the parts or ideas fit together well so that they form a united whole.” While information analysts analyze application contexts on the basis of a particular requirement analysis technique, they may find that the problem statements of the application contexts can not fit into a particular conceptual model very well. Information analysts then perform intensive coherence inferences to resolve the discrepancies. Although correctness may be the goal for information requirement analysis, information analysts believe that understanding is achieved if the information requirement specifications are coherent.

Second, understanding is a structure building process which translates the conceptual structures of application contexts into the conceptual structures of requirement analysis techniques. Three operations are important for the translation process: mapping, shifting, and integrating. Mapping occurs while an information analyst studies a substructure of an application context. The information analyst first selects a requirement analysis technique which is best suited to the substructure of the problem statements. On the basis of modeling knowledge and domain knowledge, the information analyst then maps the substructure of the application context into the conceptual structure of the selected requirement analysis technique. Shifting occurs while an information analyst decides that the information requirement analysis technique being used can not achieve a locally coherent representation for a substructure of an application context. The information analyst will then try other requirement analysis techniques. Finally, integrating is the operation that integrates the conceptual models for the substructures of an application context into a conceptual model for the whole application context with global coherence.

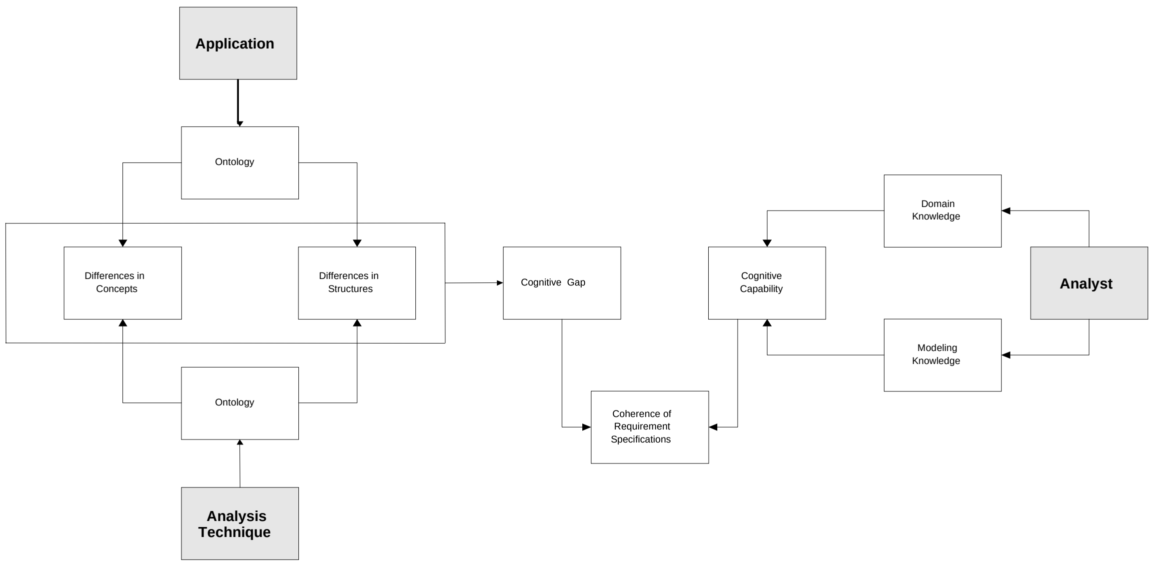

Figure 1. A Cognitive Model of Information Requirement Analysis

Third, the coherence of an information requirement specification is determined by the cognitive capability of the information analyst who specifies the information requirements and the cognitive gap between the target application and the particular information requirement analysis technique being used. The cognitive capability of information analysts can be evaluated by their domain knowledge and modeling knowledge. On the other hand, the cognitive gap between an application and a particular information requirement analysis technique can be evaluated by the difference of their ontologies. An ontology includes a set of concepts for describing an application context and a cognitive structure for organizing the concepts for the application context (Guarino, 1995). The difference in ontologies determines how difficult for information analysts to model an application context by a particular information requirement analysis technique.

A Framework for Classifying Information Requirement Analysis Techniques

In order to demonstrate the concept of cognitive gap, a framework for classifying organizational information requirement analysis techniques based on cognitive gap is proposed as shown in Figure 2. For the dimension of concepts for organizational systems, two levels of abstraction for information requirement analysis can be identified (Livari,1989). The first level of abstraction is the organizational level which defines the organizational roles and contexts of an information systems. The second level is the infological level which defines the information variables for an information systems.

For the dimension of cognitive structures, the research in cognitive science (Komatsu, 1992) and metaphysics (Pepper, 1942) has identified at least five types of cognitive structures which are coherent for human understanding. First, functionalism defines an information systems as black box machines that transform inputs into outputs (Marca and McGowan, 1993). Example techniques include data flow diagrams (McMenamin and Palmer, 1984) and process decomposition diagrams (Martin, 1989). Second, behaviorism defines the behavior of information systems from the perspective of stimulus-response relationships (Scholnick, 1983). Example techniques include state transition diagrams (Davis, 1990) and IDEF2 (Bravoco and Yadav; 1985). Third, similarity-based structuralism believes that people understand concepts about objects by categorizing the objects on the basis of the similarities of attributes of the objects (Komatsu, 1992). Example techniques include entity-relationship models (Chen, 1976), object-oriented models (Coad and Yourdon, 1991), and agent models (Bose and Sugumaran, 1996; Yu, 1993). Fourth, schema-based structuralism believes that people organize related concepts into units called schemata (Rumelhart, 1980). From the perspective of schema-based structuralism, people understand the phenomena of the real world by mapping the phenomena into the related schemata. On the basis of schema-based structuralism, scenario analysis (Holbrook, 1990; Hsia, et al, 1994; Potts, Takahashi, and Anton, 1994) has been proposed as an approach to modeling organizational information requirements. Scenarios, which are story-like schemata, are used to represent organizational information requirements. Fifth, explanation-based structuralism believes that people categorize concepts by their theories of the world (Murphy and Medin, 1985). From the perspective of explanation-based structuralism, people tend to generate theories to explain the relationships among different concepts and use the theories to understand the phenomena of the real world (Pepper, 1942). Example techniques include requirement specification reuse on the basis of infological or organizational concepts (Huang and Burns, 1997).

Cognitive Structures

Concepts		Functionalism	Behaviorism	Similarity-based Structuralism	Schema-based Structuralism	Explanation-based Structuralism
Concepts	Infological Level	Data Flow Diagrams	State Transition Diagrams	Entity Relationship Diagrams; Object Models	N/A	Specification Reuse
Concepts	Organizational Level	Process Decomposition Diagrams	IDEF2	Agent Models	Scenario Models	Specification Reuse

Figure 2. A Framework for Classifying Information Requirement Analysis Techniques

Conclusion

Current research in the process of information requirement analysis has focused on answering the question of what factors influence the performance of information analysts in specifying information requirements. In this article, we try to answer why the knowledge of information analysts, information requirement analysis techniques, and application types can influence the coherence of information requirement specifications.

Cognitive gap has been identified in this article as a measurement for the amount of cognitive capacity needed to translate the conceptual structure of an application context into the conceptual structure of an information requirement analysis technique. In order to reduce the cognitive gap between application contexts and information requirement analysis techniques, three directions for the future research in information requirement analysis techniques can be identified. First, the ontologies of requirement analysis techniques should cover more concepts at the organizational level rather than those at the infological level. Second, requirement analysis techniques should be able to cover and integrate more cognitive structures to reduce the need to shift among requirement analysis techniques with different cognitive structures. Third, the explanation-based structuralism provides the most coherent cognitive structures for human understanding (Komatsu, 1992; Murphy and Medin, 1985). Therefore, information requirement analysis techniques should be able to represent not only what an information system should do, but also why.

References

References are available from the authors upon request (onhua@ttacs.ttu.edu; odbur@ttacs.ttu.edu).